ITEM No. 8, 24 and 27
FILE No. XXVII-61

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by authority of
The Joint Chiefs of Staff,
by Col. E. W. Gruhn.

DRAEGERWERK, LUBECK
GERMANY

SECRET

COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

S E C R E T

DRAEGERWERK, LUBECK, GERMANY

Reported By

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C.I.O.S. Target Numbers 8/77, 24/324, 27/15
Chemical Warfare
Medical
Instruments & Equipment

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear), APO 413

OUTLINE

I. TARGET

A. Location

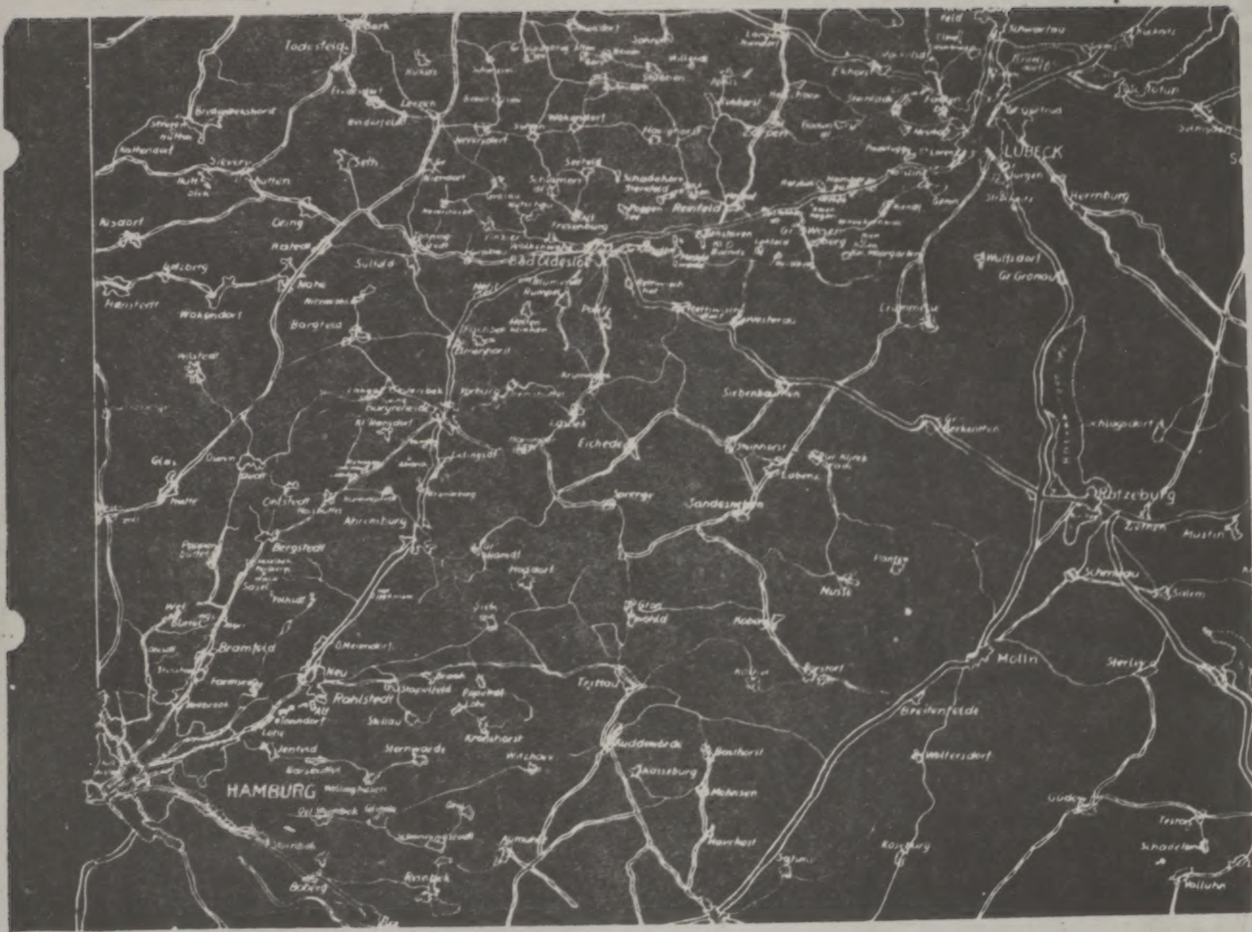


Figure 1

Location of Target

B. The Plant

The target is the DRAGERWERK, CIOS No. 27/15 - 8/77. The main plant, exclusive of its subsidiaries, is located on the Moislinger - ALLEE and consists of many buildings. These are detailed on the Geläudeplan, Fig. 2.

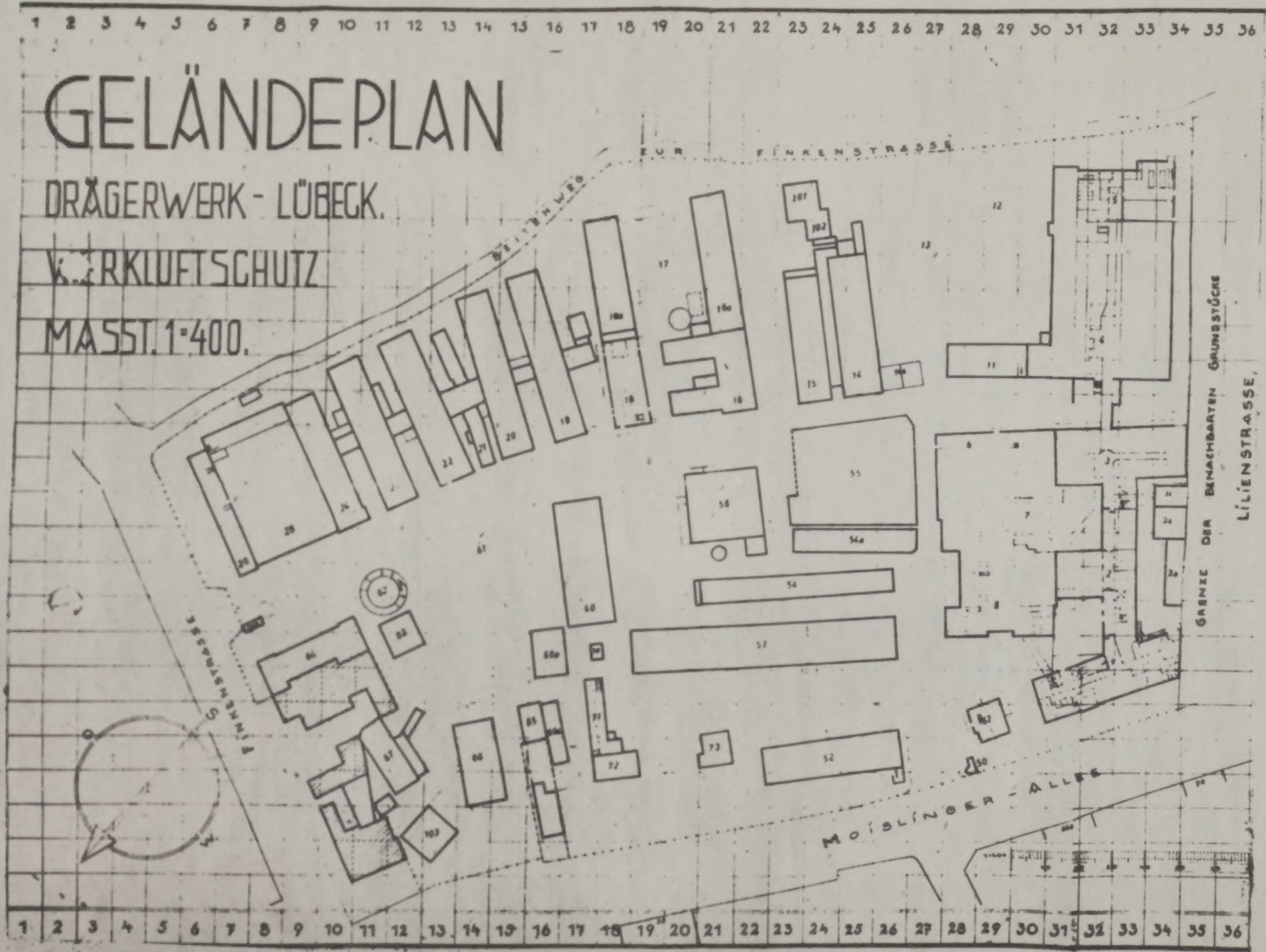

GELÄNDEPLAN
DRÄGERWERK - LÜBECK.
V. ..RKLUFTSCHUTZ
MASST. 1:400.
ZUR FINKENSTRASSE
FINKENSTRASSE
MOISLINGER - ALLEE
GRENZE DER BENACHBARTEN GRUNDSTÜCKE
LILIENSTRASSE.

Figure 2.

The number on each building relates to the following activities:

(1) Offices
(2-3) Mechanical workshops (turning and completing workshops)
(2a) pulled down
(2b) divers' testroom
(2c) testroom for oxygen-supply-apparatus
(4) surface treatment plant
(5) stamps' workshops
(6) part of foundry
(7) Diesel and steam-engines
(8) offices and magazone
(9) not existing (bombed out March 28, 1942)
(10) " " " " " " "
(11) painting workshop
(12) garden
(13) "
(14) metal press work
(14a) oxygen tank
(15) oxygen plant, workshop and mazazine
(16) chemical laboratory, offices
(16a) paper mill
(17) laboratory for low temperatures
(18) main chemical laboratory
(18a) magazine
(19-22) workshop for sewing and completing gas-masks (part of 20 pulled down)
(23) cardoxide workshop (lime preparing plant)
(24-26) locksmiths workshop
(27-49) not existing (destroyed Air Raid March 28, 1942)
(50) porters office
(51) offices (being used at present by soldiers)
(52) " " " " " " "
(53) magazine
(54) " (open boxes)
(54a) " " "
(55) foundry
(56) boiler house with compressor room
(57)
(58) not existing (bombed out March 28, 1942)
(59)
(60) testroom for ventilation apparatus and for high pressure appliances
(60a) melting plant for sodium hydrate
(61) garden
(62) air raid protection tower
(63) sleeping room for guards
(64) garages
(65) shed
(65a) "
(66) "

(67) sleeping room
(68) not existing
(69)
(70) store of inflammable fluids
(71) sewing workshop
(72) testing apparatus for metals
(73) dwelling-house out of bounds
(74-100) not existing (bombed out March 28, 1942)
(101) dwelling house of Dr. Draeger and Mr. Hinzmann, out of bounds
(102) pulled down
(103) dwelling-house out of bounds

C. Condition of the Plant

The plant suffered considerable damage in a bombing raid on the night of March 28, 1942. A total of fifty buildings were destroyed. Many of these were small and are not identified on the plan. Others, such as 57, 58 and 59 were of good size. Since the bombing, many buildings have been repaired and new ones have been built.

The plant operated up to 1930, on 2 May 1945, at which time Allied Forces entered the town. It is interesting to note here some remarks of Dr. Draeger pertinent to that incident. "At the time I happened to be talking on the long distance telephone to a representative of Admiral Donitz in Travemunde. He was informing me not to destroy anything since the English and American troops were on their way. I told him that they had already arrived and I held the phone receiver out of the window so that he could hear the tanks rumbling by."

All buildings were examined by the investigators. Those of special interest were these:

(1) The offices
(2) The divers testroom
(3) The testroom for oxygen - supply apparatus
(4) The oxygen tank room
(5) The oxygen plant, work shop and magazine
(6) The chemical laboratory and offices
(7) The main chemical laboratory
(8) The laboratory for low temperature
(9) The test room for ventilation apparatus and for high pressure appliances
(10) The store rooms

D. Operating Equipment

The operating equipment of the plant was abundant and of the highest quality. It was fully commensurate with the development and production of precision instruments for which the Draegerwerk enjoys a worldwide fame.

E. Stocks of Material.

The material stored in various magazine within the plant consisted of large stocks of raw material, incidental parts and various production items in all stages of development, from the rough to the finished product.

The stocks of material included the following:

(1) Rubber
(2) Leather
(3) Brass
(4) Plastics
(5) Aluminium (small amount)
(6) Steel forgings and castings

The stores of incidental parts contained an abundance of general hardware such as screws, nails, nuts and bolts. There were also stores of machine tools, chemical glass ware, hammer handles of all sizes, brushes, pails and an assortment of office supplies.

The stocks of production items consisted of finished parts and completely assembled items as listed in paragraph two of the report. Many of these items are described also in paragraph four and are the subject of various documents indexed in paragraph six.

The magazines containing these stocks were located in the ground floor of buildings number 2 and number 7, also the basement and the 1st, 2nd and 3rd floors of building number 8.

F. Subsidiary Firms.

In addition, the main plant maintained the following subsidiaries:

(1) Within Lubeck

(a) Hauptwerk: Draegerwerk Heinr.u.Bernh.Dräger, Lubeck, Moisl, Allee 53.
(b) Werk Lachswehr
(c) Pachtbetrieb Eisengiesserei und Maschinenfabrik Ewers & Miesner.
(d) Pumpenwerkstatt an der Trave

(e) Raumfilterwerkstatt bei Thiel & Söhne
(f) Tischlerei Märkische-Strasse
(g) Kistenfabrik Wieland-Strasse
(h) Taucheranzugwerkstatt Linden-Strasse
(i) Ausweichgiesserei im Lubecker Landgebeit
(Dissau)

(2) Outside Lübeck

(a) Dragerwerk Heinr.u.Bernh.Dräger
Werkstatt Wandsbek
Hamburg-Wandsbek

Neumann-Reichardstr. 29-33
(b) Dragerwerk, Gummiwerk Hamburg
(vorm. Skara) Hamburg-Wandsbek
Ahrensburgerstrasse 162

(c) Drägerwerk Heinr.u.Bernh.Dräger
Zweigbetrieb Sudetenland
Auperschin b.Teplitz-Schönau

(d) Fertigungsstatte des Dragerwerkes
bei der Firma Breitlung
Teplitz-Schönau
Maikowskistrasse 10

(e) Drägerwerk Heinr.u.Bernh.Dräger
Werkstatt Leipzig
Böhlitz-Ehrenberg über Leipzig
Hermann Goringstrasse

(f) Drägerwerk Heinr.u.Bernh.Dräger
Zweigbetrieb Neumünster
Kleinflecken 13

(g) Drägerwerk Heinr.u.Bernh.Dräger
Zweigbetrieb Raumluftung Neumünster
Postfach 22

(h) Drägerwerk Heinr.u.Bernh.Dräger
Zweigbetrieb Leine
Delligsen / Krs.Gandershein
Post Alfeld (Leine)

(i) Pinnau-Werke G.m.b.H.
Utersen

(j) Hochbunker Hamburg-Barmbeck
Bramfelderstrasse 10[illegible]

(k) Office Raumluftung
<u>Hamburg-Wellingsbüttel</u>
Hamburgerstrasse 79 / Herrenhaus

Only one subsidiary plant was visited namely the office Raumluftung, Hamburg - Wellingsbüttel, Hamburger street 7[illegible] - Hernhaus. This visit was carried out to obtain documents relevant to air conditioning for Submarines and Tanks.

Inquiry regarding the others disclosed nothing of interest since these were engaged mainly in activities with no special value to medicine.

G. <u>Employees.</u>

The Drägerwerk throughout Germany employed approximately 6,000 people at the peak of production in 1944.

At that time the main plant in Lubeck employed about 3,000 German workers mostly women and 1,[illegible]00 foreign workers. The foreign workers were French, Russian, Polish, Czechoslovakians and others. This information was volunteered by Mr. Drager and was evidenced also by signs in different languages placed about the plant and by records kept in a safe-room located in the basement of building No. 8 identified in Gelandeplan paragraph 1 B.

2. <u>INTEREST OF THE MAIN FIRM AND ITS SUBSIDIARIES</u>

A. High altitude oxygen breathing apparatus
B. Submarine escape apparatus
C. Diving apparatus
D. Civilian, industrial and military gasmasks
E. Oxygen cutting and welding apparatus (not under water)
F. Detecting apparatus for Carbon Monoxide, Carbon Dioxide, and other gases.
G. Breathing apparatus for hospitals and pharmaceutical work.
H. Special types of paper for various purposes, e.g. filters, bandages, etc.
I. Mine safety apparatus
J. Rubber, surgical and technical goods
K. Oilcloth manufacture
L. Preparation of "Carbidoxyd" for absorbing Carbon Dioxide in breathing apparatus in mines.
M. Air conditioning apparatus.

N. Bicycle tyres (only experimental)
O. Swimming vests for pilots.
P. Air purifying devices
Q. Pressure regulators of all kinds
R. Oxygen distributing devices
S. Anti-gas suits

3. PERSONNEL OF FIRM

A. Some of the more important personalities of the plant may be listed as follows:

Name	Title	Position in Concern
Dr. Heinrich Dräger	President	
Dr. Heinrich Maul	Production Director & Chairman of Sonderausschuss F.O. 7.	
Dr. Dipl. Ing Hans	Commercial Director and Chairman of Sonderausschuss Abwehrgerate	
Dr. Gerhard Stampe	Chief Chemist	
Dr. Ing Franz Hollmann	Chief Engineer for the development and manufacture of High Altitude Breathing apparatus	
Dr. Hermann Tietze	Chief Engineer for the development of Diving apparatus	
Dr. Meier Winhorst	Head of the Department for development of Air Conditioning apparatus	
Dr. Dipl. Ing. Heinrich Cordes	Director of Research on High Pressure armatures	
Dr. Grosskopf	Assistant to Dr. Stampe	
Mr. Steen	Chief of workshops for high altitude oxygen breathing apparatus	
Mr. Rossi	Director of Personnel	
Mr. Holdhahn	Head of Export Department (best informed on the extent of German/Jap interchange of information)	

4. INFORMATION OBTAINED

The following paragraphs give a general survey of information obtained by interrogation of the persons listed in paragraphs three above, and by perusal of documents acquired and indexed in paragraph six of this report.

A. Aviation - Principal contributor, Dr. Ing. Hollman.

(1) Parachute emergency oxygen apparatus (Ref. all documents No. 100) (Specific documents Nos. 22, 23)

a. Description
This apparatus consists of a series of high pressure cylinders which are arranged in a parallel manner to form a flat plate, about an inch thick. The diameter of the cylinder is about 3/4 of one inch. The cylinders are connected to an outlet valve through a narrow tube, which is about m long und which acts as a metering orifice. The entire assembly is flat and fits into a pocket in both the seat type and backtype parachutes. During normal flight this emergency system is connected to the main aircraft oxygen system. A ripcord attaches the parachute assembly to the aircraft seat and when the pilot wishes to leave the airplane, that portion of the emergency system which is attached to the main oxygen system is detached and the emergency oxygen flow valve is opened. For details refer to drawings and descriptions in ref. cited.

b. Operating characteristics.
The emergency oxygen system is charged to 150 atm. pressure and has sufficient capacity to last about 20 min. Theoretical and experimental flow data are in agreement. Experiments conducted with smaller and shorter orifices indicated freezing because of the adiatatic expansion of the oxygen. The long narrow tube was the solution. For further details refer to the Research Reports.

c. Future developments.
The arrangement of the cylinders in a manner to leave a hole in the center for the pilots has been considered to give greater comfort. No other changes were indicated.

d. Samples for study.
Arrangements have been made to have several samples sent to interested agencies for test and study purposes.

e. Comments.
This apparatus is unique in the German air forces and is of considerable interest to aviation. The incorporation of the oxygen apparatus with the parachute is a good idea and merits further development. The existence of this apparatus has been known for a long time but these are the first models which have been obtained. The design engineer and the manufacturer have been extremely co-operative in discussing this device.

(2) High Altitude Demand Regulators.

a. Description.
The Drägerwerk have lately constructed demand regulators only for pursuit aircraft having a high rate of climb and high altitude performance. This resulted in a regulator without the air diluting mechanism and with an aneroid capsule attached to the diaphragm to deliver about 15 mm H_2O col. positive pressure about 10 km altitude. The structural details may be seen in documents listed elsewhere in this report, pertaining to the "Umsteuerhöhenatme". With the loss of the productive capacity of the Auer-Gesellschaft in Berlin, the Drägerwerk built the above regulator with a diluter mechanism.

b. Operating Characteristics.
The functional characteristics are described in detail elsewhere (refer to the list of documents). The opening suction of the regulator is about 10 mm H_2O col. pressure sets in at 10 km. Production regulators were tested for opening pressure, pressure required to obtain flows of certain values, the volume of flow obtained by manual depression of the diaphragm, the adjustment of the aeroid, etc. In addition the check valves, oxygen indicator and pressure gages were tested for accuracy, calibration and leak of tightness. For further details of this test set-up refer to drawings and descriptions listed in this report.

c. Research Results.
Considerable research has been carried out on this high altitude regulator, the most important and greater part of the research was carried out here. The research and design of the original regulators was based on the original data from Barcroft, Haldane, etc, and the design

was not particularly based on research carried out by German agencies. For details or research on this regulator refer to the included list of documents attached to this report.

d. Equipment.
The regulator has been studied by some Allied agencies. Additional models are being evacuated however, to supplement those already existing. Several samples of the aneroid are being evacuated for further study in the automatic loading of diaphragms of demand valves.

e. Comments.
The regulators for use in the G.A.F. have all been designed and most of them built by the Drägerwerke. The performance has, in general, been satisfactory. Again the engineer and other members of the firm were very co-operative.

(3) Combination Oxygen Indicator and Pressure Gage. (Ref. All documents No. 102) (Specific Doc. Nos. 5, 6, 7, 11).

a. Description.
This is a device which indicates to the user the pressure of the gaseous oxygen (and thereafter the supply) in the cylinders as well as giving a signal at every breathing cycle of the person-regulator combination. Theoretically, non-function of the blinker indicates non-function of the regulator. The blinker is actuated by pressure acting on a diaphragm, which is coupled to two bands, visible from the front of the instruments and which are phosphorescent, which move out of view behind two plates. The mechanism is quite simple.

b. Operating Characteristics.
The operation of the blinker is not affected by vibration and by cold of - 45° C only to the extent that the leaves close more slowly. The pressure gage is calibrated at the bottom and top of the range and reads in fractions of supply rather than pressure.

c. Research Results.
The combination indicator emanated out of the idea to consolidate the pressure gage and blinker into one housing. No extensive research was conducted.

d. Equipment.
Several samples of this instrument have been evacuated for further study in connection with the central warning panel.

4. Regulator Test Instruments. (Ref. All documents 104, 110).

a. Description.
1. Universal test instrument. (Ref. documents 16, 17). This is a rotary scale instrument for the measurement of flow, positive and negative pressures to test any type of oxygen dispensing mechanism. For further details refer to the references listed in this report.

2. Oxygen purity analyzer. (Ref. Doc. No. 253) This is a manometric type analyzer using a solution of 50% NH_4OH solution and an equal volume of saturated $(NH_4)_2CO_3$ solution for absorbing the oxygen. The quantity of oxygen absorbed is indicated on the volumetric tube.

3. Demand Regulator leak tester. (Ref. All documents No. 110). (Specific Doc. 47, 48).
A device for measuring leakage in a demand regulator installed in the plane. This device measures the positive pressure upon leakage from the demand valve and negative pressure drop to test for leakage at the diaphragm, etc.

b. The operating characteristics are adequately described in reference listed in this report.

c. Research results.
The research on these instruments was only that connected with their design.

d. Equipment.
Several models of each item of equipment have been evacuated except for the regulator leak tester, of which none were available.

e. Comments.
These testing devices are all visual. The O_2-purity analyzer requires about 5 min, for one analysis and the solution deteriorates quite rapidly. The Scholander device used by Allied agencies is believed to be just as accurate and superior in other respects. The other devices are indicating mechanical devices which are practical for field use.

5. Reducing Regulators. (Ref. All Documents, No. 107).

a. Introduction.

Reducing regulators have played a very important part in industry and the armed forces of Germany. The government agencies which were interested in producing equipment such as the V 1, V 2 and submarine devices, often assumed that reducing regulators were readily obtained and therefore came to the Drägerwerke very late to obtain the proper regulator, only to learn that it had to be designed and developed. It was also learned that information as to the use of the regulator was not divulged to the engineer, except that which was absolutely necessary for the design. This resulted occasionally in the delivery of a wrong reducing valve. These procedures caused a considerable delay in the appearance of the V 2.

b. Description.

Reducing regulators have been designed and built by this firm for a variety of purposes, which are listed below:

(a) Katapult Seat. (Ref. All documents No. 107). Early trials with pilot ejection used a blast of compressed air, acting on a piston attached to the seat, to eject seat and pilot. Since ejection must be very rapid, a high capacity pressure reducing regulator was required. Such a regulator was designed and built, including a modification by which the regulator could be turned on by an explosive charge.

(b) High pressure Reducing Regulators. (Ref. Document No. 37).
Economy of space and time have led to use of very high pressure gases (400 atm). For these very high pressure reducing valves have been designed and built.

(c) Automatic compensating regulators for divers u. torpedo tubes. (Ref. Doc. Nos. 40, 41). Reducing regulators have been built for use on diving suits and submarines whose outlet flow and pressure is controlled by the water pressure. This prevents accidents in case of a sudden increase in depth of either the diver or the submarine. CO_2 gas was used to keep the torpedo tubes clear of sea water.

(d) Suspended Buoy Reducing Regulators. (Ref. Doc. No. 27).
Buoys were built by the Germans which would, after a certain period of immersion, generate gas, displace H20 and rise near the surface and emit either a characteristic sound or a phosphorescent glare, after which they would sink down from view again, thereafter to reappear at regular intervals, this intermittently marking the way.

(e) Reducing Regulators for Underwater Diesel Motor Operation. (Ref. Doc. Nos. 30, 31).
A circulatory system has been evolved to supply Diesel Engines with suitable mixtures of oxygen and nitrogen. The exhaust gases are filtered and purified, the noxious gases are dumped to the outside, and the useful gases are recirculated through the system. The reducing regulators for this system were designed and built by the Drägerwerke.

(f) Regulators for Shallow Swimming and Diving Suits. (Ref. Doc. Nos. 26, 35).
A complete rubber diving suit for bridge repair and construction has been built by an Italian Company, copied and improved by the Drägerwerke. This suit is equipped with web like hands and feet for easy swimming. When the head is above the water level air is breathed and when the head is below water oxygen is permitted to flow into a reservoir by a manual operation of the reducing regulator. These suits were service tested for repair of the Wijmegan bridge and worked quite satisfactory, although there is some objection to these suits by personnel using them.

(g) Regulator for ejection of torpedoes. (Ref. Doc. No. 41).
A high capacity pressure reducing regulator has been developed for the ejection of torpedoes in submarines. These regulators have an extremely high capacity and only a few experimental models have been built.

(h) Protective devices against explosions occurring in the lines of oxy-acetylene torches. (Ref. All Documents No. 105). (Specific Doc. No. 42)
This is a fitting containing a check valve and an unglazed ceramic disc. The check valve prevents any back flow into either tank and the ceramic disc conducts heat away so that explosive temperatures cannot be reached. A check valve

alone is not sufficient, because the explosion travels faster than the pressure wave which doses the valve. Other materials have been tried for heat conduction, i.e. glass wool, metals, etc. but unglazed ceramic has been found most satisfactory. When leakage from one line into another exists for a long time the ceramic may heat up. Hence, it is necessary to close the regulators before this happens which indicates an awareness of the situation.

(i) These items described above are only in part available, but drawings exist on all and have been requested. The engineer was co-operative in divulging information only after he had been told to hide nothing from the investigating team.

6. Pressure Suits. (Ref. All documents No. 103). (Specific Document No. 50).

a. Investigation on pressure suits for use at high altitude by aircrew has been intermittently underway since 1930. The development has been an interesting one but its ultimate use in aircraft is not considered practical, since motion and sense of touch is restricted to the extent that piloting of an aircraft is distinctly problematical. Development of this item was nevertheless stimulated by officials of the G.A.F. The development along this line was principally one of improving the leak tightness and flexibility of the joints.

b. Description.
The latest suit, of which only one incomplete item is available, is made of rubberized fabric with ball bearing joints that may be of some interest to allied agencies. The helmet is a plastic device reinforced with metallic bands. The oxygen mask used has inlet and outlet tubes and is attached to the demand regulator which is subjected to the pressure environment within the suit. The suit is equipped with two safety valves, the primary one of which has excellent flow characteristics.

c. Operating Characteristics.
The suit may either be inflated by compressed air or oxygen and ventilation is achieved only when the relief valve has opened. Oxygen for breathing is obtained through a mask from a demand regulator which is subjected to the pressure in the suit.

d. Research Results.

Research at this factory has confined itself to those aspects necessary for development. Several altitude trials have been made and these are reported in detail in research reports listed among the documents.

e. Comments.

Development of this item has not progressed as far as had been hoped. However, consideration of the ball bearing joint may be of some value to allied agencies.

7. Developmental projects of Dr. Ing. F. Hollman.

a. Development of high altitude safety pressure demand regulators.

Several methods have been developed and some of them tried, to produce a slight positive pressure to reduce the effects of mask leakage at altitude. These methods are all designed to supply an additional force to the oxygen inlet valve, to open the valve slightly and permit a positive pressure in the regulator. The mechanism has been designed to produce a positive pressure between 10 and 15 mm H20 column.

(a) Constant safety pressure.

This mechanism is activated by blinker line pressure, which pressure builds up between 1 and 3 atm. only during inspiration. The pressure is conducted to a small diaphragm which actuates a rod connected to the inlet valve, which opens slightly, producing a flow of O_2 under a slight positive pressure. A small blood orifice is provided to permit loss of pressure during expiration. The drawings and patent claims for this system are included in the list of documents.

(b) Solenoid.

To accomplish the same act a device using an electric solenoid was designed but not tried. The solenoid is actuated electrically and opens the inlet valve. This method is obviously more complex.

(c) A third method was tried to accomplish the foregoing by means of an aneroid boy, so that the safety pressure would be applied in relation to altitude. This requires the aneroid system, exposed to ambient pressures, and the system for opening the main oxygen inlet valve. This method combined with the method described in (a) suggests a scheme for producing a continuous safety pressure and a positive pressure which increases with altitude.

(d) A fourth method was presented, utilizing the positive expiratory pressure to aid in depressing the diaphragms, thus aiding the following inspiratory effort. This method has been tested and works but it is susceptible to freezing. Diagrams illustrating this and the foregoing principles are included in the list of documents attached to this report.

b. Liquid Oxygen Vaporizers for Use in Aircraft.
The engineers at Dragerwerke began to experiment with liquid oxygen installations for long range aircraft in 1943. They built one experimental converter with atmospheric heat exchanger and rapid pressure build up similar to the schemes now in use by the allies. Schematic drawings of the system and a detailed diagram on the control valve system have been obtained. The above named engineer expressed the opinion that the use of liquid oxygen installations was practical only for long range aircraft.

c. Pressure Equalizer for Demand Regulators.
To maintain a constant opening pressure and resistance to inhalation with dropping pressure in the supply system a mechanism is incorporated which tends to equalize the forces on the oxygen valve. The methods for accomplishing this are variable but all embody the principle of the force of a spring counteracting the force of the pressure exerted on a known area. A new scheme for doing this has been developed and the patent claim drawings have been obtained.

d. Automix Valve Opening Scheme.
To insure against a high percentage of air or all air inspiration in shallow breathing it is necessary that the automix valve be opened by operating of the injector. To accomplish this a pressure line has been connected from the blinker line to the valve opening mechanism in the automix box. Patent claim diagrams have been obtained.

e. Goggles for Spray Painters.
To prevent the accumulation of paint on goggles a flow of compressed air is emitted from the upper and lower rim of the goggles. The air stream prevents the accumulation of paint on the goggles.

f. Demand Operated Reducing Valve.
A small reducing regulator has been designed which is actuated by small negative pressure. No model of this device has been built and many engineering problems will probably present themselves upon construction.

B. Submarines - principal contributor, Dr. Meier-Windhorst.

(1) These annotations are concerned mainly with air-purification systems. The reference numbers are those put on the original documents sent through CIOS. Extracts made from some of these documents bear corresponding reference numbers but are not comprehensive, being abstracted from files, the reproduction of which could not be undertaken in its entirety on the spot.

(2) Information not concerned with air-purification systems is also included here, but unlike that substantiated by documents it should be treated with reserve as the informants were often speaking outside their field and were not directly concerned with such aspects of development.

(3) Unless otherwise stated the documents referred to were obtained from "Herrenhans", Hellingsbuttel, Hamburg. This plant was visited with the Leiter, Dr. Meier-Windhorst from whom much of the information was obtained. "Herrenhans" was a Drägerwerke subsidiary and consisted of a few offices sublet by Firrma Zampi which manufactured nautical clocks and Chronometers. It was used freely as a drawing office and drawing repository subening manufacturers in Hamburg.

(4) Small Underwater Craft. (Ref. Documents Nos. 201-208; 210-214; 220-222).

a. The necessity for air purification in these craft entails the design and development of a less bulky system of air-purification than that incorporating a fan and motor. This was particularly essential in craft designed on the torpedo principle, where the occupant(s) were enclosed in the craft, but was extended later to the midget submarines.

Dr. Nielon, at Drägerwerke, designed the 'Umwalzinjektor' which made this possible. His whereabouts were not known.

b. Oxygen from aircraft pressure bottles passes at 200 Kgm/cm^2 to a pressure gauge and flow gauge through an on-off valve. The pressure gauge records bottle-pressure in Kgm/cm^2. The flow gauge is marked 1 and 2 on its dial indicating the oxygen requirement for one and two men respectively, as in "Seehund K" Ref. 226(a). In the case of a one man craft, the single indication on the dial is 0.6 liters, which refers to the oxygen flow per minute, Ref. 226(b)(c). Flow was regulated by a screw-down valve. Flow gauges were luminescent, and were constructed in one unit with the pressure gauge. Gauges marked with flow requirements for 4 men and 8 men were seen in the store at Drägerwerke and are said to have been used in aircraft.

c. From the gauges a reducing valve then delivers oxygen at 55 atmospheres to the injector.

d. The injector is a Venturi system delivering a 1:50 oxygen to air mixture. Great difficulty was experienced in obtaining this ratio, but was overcome by constructing the injector as a double Venturi. For each type of craft in which this principle was used, alterations were necessary in the details of construction. Most of these are covered in the full references. Diploma Engineer Köppl at Drägerwerke was responsible for the experimental development of the injector principle, Dr. Meier-Windhorst acting in an advisory capacity.

e. Two types of installation for air-purification were used, the second an improvement on the first.

At first, air was drawn from the craft through the injector, and the mixture with oxygen was passed into a soda-lime canister (Kalk-patrone). This was single in the smallest craft, but in larger two-man craft, two canisters in a light metal rack were used joined together by a corrugated tubing yoke. After passing through the soda-lime, the clean air-oxygen mixture was delivered by a hose-pipe lead near the occupants. Should the pilot require to conserve oxygen, and stop the flow through the injector, he simply plugged a hose-mouth mask on a corrugated hose

into the adaptor in the open end of the outlet tube. He then drew air through the injector and soda-lime during inspiration through an inspiratory valve in the mask. At expiration, exhaled air closed the inspiratory valve and opened an expiratory valve also in the mask, so breathing out into the compartment. This had the advantage of keeping the 'dead-space' small but the disadvantage that the air in the compartment accumulated carbon dioxide. Resistance through the injector and soda-lime at inspiration was 12 mm H20 for a flow of 30 litres/minute and 60 mm H_2O at 160 litres per minute. As the former was found by trial to be the average requirement, no trouble was experienced due to resistance.

f. In later models it was found preferable to make the pilot exhale through the soda-lime so preventing an accumulation of CO_2 in the compartment. The canister was then placed in series with the air-intake of the injector and instead of plugging his mask into the delivery hose, the pilot plugged into the canister, when the injector was not in use.

g. All the components used were either aircraft stores or were of similar light construction. Samples of the essential features were forwarded through CIOS to this country, or where only obtainable at the last moment brought back by the team. This applies to the injectors which had to be made.

A model section showing the installation for "ManderII" was seen at Drägerwerk and impressed one with its compactness.

h. It is of interest to note that Drägerwerk on request devised a larger injector on the same principle to disperse battery gases in large S/Ms, by mixing these gases with the air in the craft. This was done because a hydrogen 'absorber' of which no details could be obtained, had been thought to be responsible for half a dozen explosions. This large injector was fitted in Type 21 S/Ms.

i. <u>Types of small underwater craft.</u>
Listed in order of their development.

(a) "Hecht". Fifty were constructed mainly for experimental purposes, but some are thought to have become operational. Built on the torpedo principle with a detachable war-head. Powered by an electric motor. Not fitted with injector principle.

(b) "Neger". Known to us as "Mother-and-Child". Was not fitted with an injector, so that the pilot had to wear his mask continuously. This is said to have caused considerable embarrassment. Built on the torpedo principle, but carrying the torpedo proper slung beneath it. Powered by a benzine engine.

(c) "Molch". Successor to Neger, but fitted with the injector principle for air-purification. Also of the torpedo-like construction, but nothing else known.

(d) "Mander I" and "Mander II". Parallel developments to "Molch". Mander I was not, but II was fitted with the Sauerstoffzusatzregelventile mit Umwalzinjektor. Also of the torpedo-like construction and powered by an electric motor.

(e) "Hai". Never reached the stage of production, It was a transition stage between a torpedo craft and a small S/M/ It was powered by a Diesel or benzine engine and was capable of 22 knots submerged for a period of 1-2 hours. Its build which was laterally flattened, (like a fish) prevented use of full-speed on the surface, which effectively was not more than 6 or 7 knots. Submerged endurance was 60 hours, making CO_2 absorption and oxygen replacement essential. This was done on the injector principle.

(f) "Biber". The first midget S/M proper, was made to carry first one, then two men. It was constructed by the Flenderwerke in Lubeck. Two electric torpedoes were carried in recesses above and outside and above the fuel tanks which latter were in a bulge forming the keel.

(g) "Seehund" was the most successful of the small S/Ms, and the latest version excepting the Walter Craft (g.v.). It was made at the Germania Werft, in Kiel and the Kleinverbande in Neustadt. See Ref. 207, 208. It was fitted with injector air-purification and was powered by an engine.

(h) Dr. Malony (Stalsartz), teacher in the Institute of Hygiene, Kiel University, holding the rank of Obercommando Kriegsmarine, was the medical supervisor in connection with small underwater craft, and is mentioned in at least one of the documents forwarded to CIOS.

(5) Large Submarines. (Ref. Documents Nos. 206, 209, 216-219, 224, 228, 229(a) and (b).

(a) Nassogen. (Ref. 209).
An additional method to cylinder stored oxygen, of producing oxygen in Type XXl S/Ms. The compound, which was in briquette form, consisted of potassium chlorate and iron filings. Manganese dioxide was used as a catalyst. Some difficulty was at first experienced in removing carbon monoxide but this was overcome. Oxygen production was about 150 litres per kilogram. Combustion of the briquette was started by striking a knob on the top of the generator with a hammer. This ignited gun-powder; ignition could also be started by means of barium peroxide. The generator was constructed by Auergesellschaft in their factory at Oranienburg, Berlin. The briquette was manufactured by I.G. Farbenindustrie.

A method of producing oxygen, not used in S/Ms, but believed to have been used in mines, was by the use of 'proxylen'. This was apparently simple sodium peroxide and had the advantage that the resultung hydroxide absorbed carbon dioxide.

(b) Ventilation Lay-out. (Ref. documents Nos. 228; 229 (a) and (b)).
Plan 228 shows the lay-out for ventilation plant and Freon (Frigen) plant in S/Ms Type IXD.1.

Plan 229(a) and (b) shows the ventilation layout for large U-boat supply S/Ms.

The plant was designed by Drägerwerk and was then fitted in the hulls at their respective building yards.

The above plans are copies received by Drägerwerk from these yards which were: The Deutsche Schiffe u. Machinenbau, A-G Werk, A-G "Weser", in Bremen, and the Deutsche Werke, Kiel.

(6) Silenced Motor for CO_2-absorption Unit. (Ref. Nos. 218; 219; 224).

Stated to be a most successful unit. An example has been brought to this country. The unit is numbered L200/U1. It was developed in Drägerwerk as a silent motor to circulate foul air through soda-lime cartridges in S/Ms. Its delivery, indicated by its number, is 200 cubic meters per hour at a pressure of 90 mm wat r. Sound level is 35-40 phones at 0.5 metre.

Its success was such that the principle was used in the construction of main ventilation fans, which were simply larger versions, L1000/U1 delivering 1000 cu. m. per hour and L4000/U1, delivering 4000 cu. m. per hour. These larger versions were not sufficiently silent to enable them to dispense with L200/U1, which was installed in addition. L200/U1, having sucked air through the soda-lime cartridges delivered straight into the main ventilation trunking.

(7) Soda-Lime container. (Ref. No. 217).

Drawings of this container.

(8) CO_2 - Verdichter (No. 216. Ref. No. 216).

This compressor, also used for CO_2 clearance and other purposes is an adaptation of a Swedish patent: Schraubenradverichter, made by Firma Ljungström Angturbin, Stockholm. It is thought to be of the same type as the Ims telemstor pumps fitted in British S/Ms.

Dr. Meier-Windhorst was most enthusiastic about its possible applications, and Drägerwerk had drawn the licence to manufacture.

The compression ratio is 4:1, varying proportionally with the incoming pressure. Advantages are that it is practically frictionless, requiring no oil, graphite or other lub icant, thus saving weight. The action is pump-like and not centrifugal, giving good compression against back-pressure. High speed of rotation ensures an even flow.

(9) <u>General Information.</u> (Information from Fritz Elschner, voluntarily found and introduced by Dr. Dräger.)

(a) Experiments had been carried out in Berlin on a torpedo which pays out wire as it leaves the S/M. Sounds made by the target are picked up by a hydrophone in the torpedo and relayed to the S/M down the wire. Controlling signals are likewise relayed to the torpedo in this wire. Its trials have given the impression that it would have 'revolutionized torpedo warfare'.

(b) <u>Automatic hydroplane control</u> has been developed and one such device was produced by the Ascania Werke, Berlin. The principle was gyro-controlled and necessitated forward motion of the S/M.

(c) <u>Automatic device for stop-trim.</u> Successfully used at sea. There were two forms. One depended on sea-pressure operating a hydrostatic valve which in turn controlled either the flooding or blowing of tanks. The other method was controlled by means of a membrane manometer. The required depth was set on the manometer after which the vertical acceleration of fluctuation caused automatic compensation by flooding or blowing tanks.

A manometer with a depth scale beside it having also marked on it the parts of the S/M above or below sea-level at given depths was seen in the Germania Werft at Kiel, in the control room of a submarine, and may have been a device similar to the latter description.

Depth-keeping was said to be good with fluctuations but the main advantage appears to have been that the S/M could lie with its motor stopped.

(d) <u>Underwater signalling and echo-sounding</u> were operated on the principle of magneto-striction. From questions it was deduced that they did not use piezo-electric quartz for signalling or hydrophones. Polarised light was not used in signalling, but latterly infra-red apparatus had been used between S/Ms for that purpose and possibly for detection.

(c) Schnorkel. The drop in pressure on sea-closure of the Snort was not considered serious from the view-point of the crew. Pressure in the boat fell from atmospheric, almost linearly, to about 600 millibars over so_e 5 minutes, then the engines stalled.

Schnorkel was also fitted with a form of radar to detect aircraft.

(10) Purification. (by Dr. Stampe).

(a) Elimination of carbon dioxide.

In the beginning of the war only alkali-cartridges (L.Patronen) were in use. They contained lumps of caustic soda spread in folded sieves. The caustic soda contained small amounts of impurities such as the oxides of alumium, calcium, magnesium as well as sodium carbonate and traces of copper oxide.

Soda-lime cartridges (Alkalipatronen - L - (K), distinguished by red marks) were introduced early in 1944. The particular soda-lime employed contained about 15% water and 2% NaOH.

The more recent types of submarines were not supplied with cartridges. Instead, they were fitted with containers for loose soda-lime through which the polluted air was passed. The supply of soda-lime was taken aboard in boxes.

As a new development, it was planned to dispense with the cartridges and boxes by storing the soda-lime in a compartment of the U-boat itself. The polluted air was to be passed through the whole compartment. This seemed possible in view of the fact that the resistance of the soda-lime is not altered by its use. The Germans contemplated using a layer of soda-lime about 100cm deep, with a cross section large enough to minimize the resistance to air-flow.

(b) Removal of Carbon-Monoxide from Submarines. (by Dr. Stampe).

The possibility of CO poisoning arose only in "Schnorchel"-boats, especially when the boat had

to dive quickly and the connection with the open air closed instantly. At one time only the ordinary L-cartridges were used. These contained silica-gel impregnated with calcium chloride as a drying agent and Hopcalite for oxidation. Because of the limited service-time of these cartridges a new development was adopted, namely, a connection between the exhaust and intake of the motor. This connection opened automatically when the open air vent closed. In addition, all spots of the motor where leakages were expected were connected with the intake. Thus a closed circuit was effected when the "Schnorchel" - vent became submerged.

CO intoxication was eliminated in the 1-man submarine by tightening and gas proofing the wall between the motor-room and the man-room of the craft.

(c) Observations of air-conditions in small type U-boats.
By aid of the Drager CO-recorder the amount of CO present in the air was continuously controlled. Simultaneously the concentration of fuel-oil vapors was observed by means of the Drager-hydrocarbon-recorder.

(11) Partition and solubility of carbon-dioxide in water.
As a contribution to solving the problem of driving dived-U-boats, experiments were made relative to the speed of solution of CO_2 in water and the size of bubbles formed, thus determining the rate of their rising to the surface. It was found that there would be no difficulty in dispersing the fuel gases fine enough to avoid the bubbles appearing at the surface.

(12) Lacquer for varnishing the inside of lime-canisters in order to resist alkali corrosion.

"Ebano III"
cementing solution:
60% mexphalt (softening point 55-65°C)
40% test-benzine (petrol)

Rolling varnish:
15 parts cementing solution
7 parts jeweller's rouge

Spraying Lacquer:
15 parts cementing solution
7 parts jeweller's rouge
10 parts of petrol

(13) Booster pump

(a) A large pump erected on a truck with a battery of oxygen bottles had been constructed for the Luftwaffe. It was used for filling the oxygen bottles in aircraft. Manufacture of this pump was discontinued by the Drägerwerk. All documents and drawings were handed over to the MACO Mfg. Co., Erfurt.
(b) Booster pump, GMI (name for N20). This pump was used for oxygen feeding of high altitude motors. The liquid gas was introduced into the gas tanks of the planes. Only a few of these pumps have ever been delivered. The Drägerwerk had no information regarding the success attending their use.

(14) Developmental Projects. (S/Ms). (Documents Nos. 215, 227(a), (b), (c) and (d)). Principal contributor, Dr. Dräger.

Two separate developments are indicated:

(1) The 'Kreislauf' engine
(2) The 'Walter' engine.

(a) The 'Kreislauf' engine.
A project to produce an oxygen internal-combustion engine for small S/Ms, initiated by Dr. Dräger in 1936 and developed up to 1942. The engine is fully described in Ref. 215. A prototype was built at the Forschungs Institut in Stuttgart, where Prof. Dr. Ing. W. Kamm is 'Leiter'. Concerned in the development were: Dr. Ernst of the Forschungsinstitut and Herr Koch of Drägerwerk. Dr. Ernst had been concerned in the development of a petrol-compressed air combustion engine. Dr. Meier-Windhorst of Drägerwerk suggested (according to himself) the introduction of oxygen prior to combustion and during compression. No further development occurred after 1942.

(b) The 'Walter' engine.

(a) Constructed by Dr. Walter at the Germania Werft, Kiel. Consisted of a benzine-H_2O_2 gas-turbine engine. It was designed to have a speed of 18 knots under water, for 3-4 hours, and a surface speed of 8-10 knots. Three or four of these craft were built with a displacement of 250 tons. Two torpedoes were carried internally in tubes, but could only be loaded from outside. It was found that by cooling the exhaust gases, the condensation of water-vapour from the superheated steam produced, and the dimunition in volume, combined with a Verdichter (c.8) to exhaust the gases from the boat increased the power by 50%.

(b) A Walter-craft was inspected at the Germania Werft, but a full description is outside the scope of this report.

(c) Walter was stated by Dr. Ebschner to have produced a turbine torpedo working on the same principle with a speed of 60 knots.

(c) Diving Apparatus. Principal contributor, Dr. Tietze.

(1) Underwater Escape Apparatus - "Touchretter". (Ref. Document No. 53).

This apparatus is the subject of a report by the Underwater Physiology Subcommittee of the Medical Research Council - R.N.P. 45/171 over U.P.S. 55. The summary of the report is as follows:

a. Six Tauchretter have been examined and a detailed report is presented.

b. They are similar in principle to the D.S.E.A. with the following differences:

(a) The Touchretter has a prefilled canister.

(b) The CO_2 absorbent in the Touchretter is considerably less efficient than in the D.S.E.A.

(c) The Touchretter has a large counterlung with an exhaust-valve of moderate resistance at shoulder level; (the D.S.E.A. counterlung is about half the size, with an exhaust valve of low resistance at waist level).

(d) The Touchretter has no separate buoyancy bag, and no apron for retarding ascent.

(2) Small submarine diving apparatus.

This apparatus was developed by adding a mask and a suit with weights to the Touchretter. It was designed for short-time work on small ships. The apparatus was not without criticism, however, primarily because it was without a constant oxygen supply.

(3) Diver's decompression chamber.

This chamber is a small, light, easily transportable and collapsable unit. It was intended for use aboard small vessels not able to afford the space necessary for the large stationary chamber carried on large vessels.

(4) Diving Apparatus for Meeneseinzelkämpfer (underwater swim suit). (Ref. Document No.258)

(5) Taucher-Pressluftaulage (Diver's compressed air installation). (Ref. Doc. No. 51).

D. Tanks - Ventilation and Air Conditioning. Principal contributor Dr. Meier-Windhorst. (Ref. Documents No. 223).

Documents and drawings describing the projected installation of ventilation systems in Tiger B and Panther G tanks. The blower was run off the engine. Normally when gas was not present, air was drawn through a dust-filter from outside before circulation. When a gas-alert was in force, a lever was thrown which uncovered a separate anti-gas filter (activated charcoal and particulate-gas filter). Outside air was then sucked through the dust and gas filters in turn before circulation. Air pressure in the tank was maintained 3-5 m.m. H_2O above atmospheric pressure, preventing inward diffusion of gas.

Although one of each type of tank was fitted, the system was not incorporated universally, but not because of its imperfections.

E. Air Raid Shelters - ventilation and air-conditioning Principal contributor Dr. Meier-Windhorst. (Ref. Documents No. 225).

Three drawings show the general lay-out suggested for anti-gas shelters. Pressure inside was kept 3-5 m.m. H_2O above that outside. This was done by putting two light metal swing-doors on the pipe delivering to the shelter. The end of the pipe, to which the swing-doors were fixed, was chamferred, so that with no pressure to keep them open they shut by their own weight. This was found to be simple and effective. Though normally driven by an electric motor, the fan could be hand worked through a glaring and chain drive if the power failed.

A Swiss project ('Eidenössische Materialprüfung und Versuchsanstalt für Industrie Banwesen und Gewerke Zurich. Untersuchungsbericht No. 1601, 10-11 July, 1939) was tried out, but even with a very powerful suction it was found that only 5 cubic metres per minute air, could be sucked through the earth filter. The project was abandoned.

F. Chemistry - Principal Contributor Dr. Stampe, (Ref. Document No. 260).

(1) General Remarks: Most of the work done in this department dealt with gas detection, elimination and air purification.

(2) Oxygen: estimation of.

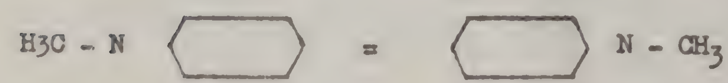
a. Research concerning this started many years before the war in connection with miners' rescue work. At first, the method used to determine the concentration of ambient oxygen employed a solution of titanic chloride and methylene blue contained in an evacuated ampoule. This solution was abandoned however because of the extreme light-sensitivity of the titanic chloride. Research along these lines eventually continued because in the early part of the war there was no military interest for an estimation of oxygen. During the last year of the war, however, interest was aroused concomitant with the development of small submarines, ventilated by oxygen injected

through a venturi. In general, three main lines of work were followed.

(a) Pyridylium-violet method proposed by Dr. Knoevenagel, Chemical Institute, University of Rostock. Knoevenagel found that the pyridylium-violet invented by him became colorless on addition of oxygen.

The pyridylium-violet is prepared by reduction of NN-Dimethyl-Dipridylium-Methylsulfate, in ammoniacal solution. By this

process a brown sediment is formed. This sediment is mixed with the same amounts of NN-Dimethyl-Dipyridylium-Methylsulfate as used for the reduction. An additive compound is formed, the pyridylium-violet. The formula of this compound is not known. The brown sediment, as formed by the reduction, seems to have a quinvid structure.



The deep color of the pyridylium-violet is probably caused by the combination of quinvid and benzolic structures in the compound. It is supposed that the pyridylium-violet looses this deep color by oxydation, because in presence of the quinvid compound the NN-Dimethyl-Dipyridylium-Methylsulfate is transported to a similar structure. This explanation is not quite satisfactory but Stampe knew of no other possible reaction.

Lumps of silica-gel or of glass are then impregnated with the pyridylium-violet and placed in small glass tubes while under oxygen-free hydrogen.

This method of estimation however did not satisfy Stampe because traces of oxygen could not be removed from the carrier-substance; the lumps of silica-gel or of glass never became impregnated with a uniform layer of the pyridylium-violet; and finally because the pyridylium-violet was difficult to prepare.

(b) Sodium hydrosulfate method.
In a small bottle of about 100 cm^3 capacity, a solution of sodium hydrosulfate containing methylene blue as an indicator is shaken with a given amount of air. The hydrosulfate must be exactly weighed and brought into the bottle as a dry powder. The time necessary for the oxydation of the hydrosulfate is a function of the oxygen percentage of the air tested. Knowing the measured time, the oxygen contents can be estimated with the help of an empirically drawn graph. The temperature of the reaction-fluid must be controlled since it influences the rapidity of reaction.

In a later development, the correct amount of hydrosulfate was introduced into small glass ampoules with thin walls.

(c) Another method still in the developmental phase was also described as follows:

A weighed amount of Pentaphenylcyclopentadienyl is impregnated on glass lumps by a process in which oxygen is avoided. Therefore a porous carrier would not be suitable.

The impregnated glass lumps are placed in an evacuated ampoule of known volume, or in a glass tube containing an inert gas at normal pressure. A measured volume of the air to be tested is sucked through this tube by means of a pump. Color changes from deep violet to a slight yellow color depending upon the concentration of oxygen in the air.

b. O_2 Umfullanlage (oxygen transfer system). (Ref. Document No. 52).

c. Helium and Oxygen.
The Germans wished to carry out experiments with a mixture of helium and oxygen but could not do so because they were never able to obtain enough helium.

(3) Carbon-dioxide.

a. Drager CO_2-Messgerät (meter). (Ref. document No. 21.)

A meter of this type was captured at the Submarine Medical Research Institute, Carnac, France, as mentioned in a report of that investigation COMNAVEU 00651 over RNPL 7/45. Furthermore, it is the subject of reports RNPL 6/45 and of TR/PG/10944/NID.

It is sufficient to summarize here some of the criticisms of the meter recorded in the report by RNPL. They are as follows:

(a) There is an error ranging from + 20% to -30% in the meter value obtained.

(b) Considerable training is necessary to operate the meter.

(c) Oil from the manometer was sucked into the chamber for the gas sample, thus interfering with the analysis.

b. Combined CO_2 and O_2 Indicator. (Ref. Document No. 260(1)).

This instrument is the subject of report RNPL 6/45, page 14 which concerns an instrument discovered at Carnac. The origin of this instrument was not known at the time of that report. It is now ascertained that the instrument was made by the Dragerwerk to the order of Dr. Lepel, the head of the Carnac Institute who had seen the individual CO_2 and O2 estimators labelled (1) and (2) in the first plate attached to the document cited. Dragerwerk knew nothing of the performance of the combined estimator. They stated that it had been delivered to Carnac just prior to evacuation of that Institute in 1944. This was but a few months before our arrival in Carnac to investigate the Institute.

(4) Carbon Monoxide.

a. Drager - CO - Indicator (Ref. Documents 253(1), 260(3a)).

The carbon monoxide indicator consists of a double acting, hand operated suction pump and a series of small, unsealed glass tubes. The tubes contain

silica-gel for absorption of hydrocarbon and Iodine pentoxide for the indicator. To obtain a quantitative indication, ten strokes should be made with the pump and then a color comparison with a standard chart to determine the quantity.

b. Drager-CO-Meter. (Ref. Documents 260(3), 253(2)).

c. CO-Meter. (Ref. Document 260(2)).

By use of this instrument the estimation of CO is reduced to a reading of the temperature by the heat of oxidation of CO. It is superior to the Drager-CO-Meter in that it employs a differential-thermometer based on vapor pressure.

The apparatus consists of a differential thermometer consisting of two arms and a common center piece. The lower portion of the two arms are filled with mercury, filled with a fluid (described in literature listed in the index) and sealed by two metallic ends of high thermal conductivity. One of these ends is embedded in a container of hopcalite, which acts as a catalyst for oxidation of CO_2. This process generates heat which is measured by the differential thermometer. The other heat contact is imbedded in a substance having a heat conductivity similar to the hopcalite. The instrument has a lag of 5 to 7 minutes with increasing CO concentrations and 10 min. with decreasing concentrations. The instrument will indicate CO concentrations of the magnitude of 0.025% by volume. The limit of the scale is 0.2%. Use of this instrument at lower than atmospheric pressures will probably necessitate recalibration. This instrument is well designed and built and has a wide application. It merits further investigation.

G. Chemical Warfare - Principal contributor Dr. Stampe. (Ref. Document No. 260 (4)).

(1) General Remarks.

Most of the work done in the Chemical Department related to gas protection. This work was the primary object of a separate team of investigators from CIOS. Therefore, the following is considered to be only a general summary. The lines of main research work are recorded in the document cited. They relate to the following paragraphs.

(2) Method for testing used gas mask canisters.

CO_2 was used, but found not efficient if the canister had been exposed to hydrocyanic acid or

arseniated hydrogen. Radium emanation was found effective of chloropicrin had been used.

(3) HCN Canister.

Charcoal impregnated with copper-salt-solution, then dried, and impregnated with caustic alkali and again dried seemed to be the method of choice. Pumice replaced the charcoal in a later method.

(4) Arsine.

Silver nitrate impregnated charcoal was employed.

(5) Regeneration of contaminated canisters.

Waterstream was used. A six-fold regeneration was obtained. The efficiency of the canister decreased slightly after repeated regeneration.

(6) Breathing Line.

Experiments were not concluded. A minimum of soluble alkali was achieved by strict regulation of the water contents. Strontium or barium allowed the water-contents to be lowered down to 12%.

(7) Attempts to substitute charcoal with efficient, yet cheap and easily available substance.

Tests were conducted with sand, soil, leaves and wood shavings. Tests were incomplete.

(8) Test for demonstrating rusting zones on ready-made canisters.

Canister rust spots become visible when the canister moistened with a dispersion of magnetite dust (magnetic iron ore) in petroleum is introduced into a strong magnetic field.

(9) Equipment for cleansing textile-fabric contaminated with poison gas (mustard).

Benzoline used as the solvent. The benzoline contaminated with mustard was then passed through bleaching (chloride of lime).

(10) Detection of poisonous gases (mustard gas).

Method adopted is based upon reaction with gold-chloride and chloramine-T. Latest improvement: exchanging chloramine-T by sodium-p-nitrophenyl-anti-diacetate.

(11) Impregnation of tunics.

Involved the use of active chlorine; substances containing NH2-groups, but these were inferior to chloramides; synthetic resins such as polymeric

acrylic-acid-ester, effect was comparable to that of amino-compounds.

(12) Manufacture of "gas-tilts" for liquid mustard.
Paper was coated with a caseine solution containing hygroscopic inorganic salts as softening agents. The caseine-coating was subsequently hardened with formaldehyde.

(13) Heat and Cold Resisting Glue for Filters.
To compensate for the lack of the formerly used Mexphalt the following mixture was employed.

30 parts of pitch (softening point 65° C.)
20 parts of tar (beginning to boil at 200° C).
30 parts of bolus alba
6 parts of sawdust

The mixture has a softening point of 70° C and a boiling point (brittling) of - 5° C.

H. Miscellaneous. Anesthesia and inhalation apparatus. Principal contributors Dr. Ing Cordes and Eng.Joseph Hunt.

(1) Anesthesia and Inhalation Apparatus. (Ref. Document No. 253).

a. Introduction.
The majority of this apparatus was designed and built before the war and hence no striking developments exist. Since in German medicine anesthetists are not specially trained for their job, the machines have to be fool-proof. The three developments which deserve mention are:
1. the use of a heated plate for vaporization of the ether, to raise the temperature of the gas mixture at the mask. This decreases the chances of ill effects on the respiratory tract and decreases the severity of the after effects of narcosis. The plate is kept at a constant temperature of 60° C by an electrical heater.
2. The use of an aspirator to introduce liquid medicaments into the narcotic gas mixture.
3. The use of a water check valve and a filter on the exhalation side of the circuit to give an indication of breathing and take out the ether not utilized. This prevents the accumulation of ether in the operating room. Another development is the use of conductive rubber on

the wheels and tubes of anesthesia apparatus to prevent the accumulation of static electricity. Electric conductors to ground are also supplied to the machine and the operating table.

b. Description.

The description of the anesthesia and inhalation devices are adequately described in the literature on this subject, of which a list is included in this report.

c. Comments.

The engineer in this department, Eng. Joseph Haupt, worked on a constant flow system for a Ju 52 for evacuation of wounded from Africa. He also developed the douche valve for the swim suit previously described.

(2) Drager Pulmotor. (Ref. Document No. 253).

This apparatus had a wide use for the treatment of carbon monoxide intoxication and for the resuscitation of drowned people. It was issued by the German Navy.

The latest type pulmotor examined delivered both positive and negative pressure. The negative pressure experienced by one of us was far too high for comfort.

(3) Therapeutic Oxygen.

Interrogation disclosed that the Germans also had vivid discussions relative to the therapeutic use of oxygen. The principle of constant oxygen supply was finally chosen. This was based on experiments carried out by Prof. Flurry in Würzburg who showed that long inhalation of pure oxygen by animals was injurious. This effect had not been observed in healthy men, but there was considerable doubt regarding it in gassed cases.

(4) Heat-producing preparation (chemical heat) for heating tinned food.

Composition:

1.0 kg. Fe pulv.
1.5 kg MNO_2
0.1 kg CuO
0.15 kg Al pulv.
1.2 kg BaO_2
0.1 kg. MgO

180 gr. of this preparation heated a 1 kg tin to 60° C. in 8 minutes time. The combustion is nearly smokeless.

(5) Anti-dimming work.

The chemical department was also engaged with the development of substances to maintain clear vision through aircraft cabins, and eye pieces of gas masks. Nothing was accomplished as far as aircraft is concerned For gas masks, however, an anti-dimming fluid was developed, manufactured and sold. This fluid has the following formula:

1. 30 kg Igepal C, high concentration
2. 50 kg Polyglykole
3. 50 kg ethyl or isopropyl alcohol
4. 1 kg Nekal Bx, dry

The substances 1 and 4 were supplied by I.G. Farbenindustrie, Frankfurt (Main).

I. Articles manufactured by the chemical Department are itemized in document No, 260 (5).

5. Instruments and Apparatus Acquired by Team.

The following items have been forwarded to the Secretariat of C.I.O.S. as prescribed.

Box I.

1. 1 Rz 15
   Leak and flow tester for breathing apparatus

2. 1 CO_2-Messgerät
   CO_2 measuring apparatus

3. 1 Ergänsungskasten z. CO_2-Messgerät.
   Can of refills for CO_2 measuring apparatus

4. Hygrometer
   Hair Hygrometer

5. 3 Gasspürpumpen
   Pumps for gas detectors

6. 4 Zungenklammern
   Tongue clamps

7. 6 Dtzd. Rückholfedern f. Druckmesser
   Dozen springs for pressure gages.

8. 1 Druckmesser 1-4 Mann
   Pressure gage graduated in 1-4 men

9. 1 Druckmesser 0-2, 5 kg/cm^2
   Pressure gage to 2, 5 kg/cm^2

10. 1 Aufdornvorrichtung 4 Ø x o,75
Flaring tool.

11. 4 Druckminderer (f. Messerschmitt) D 6670
Pressure reducing valve D 6670

12. 1 Schwimmweste
Life jacket (mae West)

13. 1 Verschlussventil gross (Sauerstoff) f U-Boote
Valve for bottle.

14. 1 Druckminderer m. Einstellung D 6260
Pressure reducing valve D 6260

15. 1 GM 38 mit Filtereinsatz
Gasmask Mod. 38 with canister

16. 1 GM 30 ohne Filtereinsatz.
Gasmask Mod. 30 without canister

17. 2 O -Anzeiger
Oxygen indicator (gage combined with blinker)

18. 1 Filtereinsatz A 95
Canister for Gasmask

19. 1 " B 90

20. 1 " K 90

21. 1 Atemmaske f. 1 Mann-Torpedo
Breathing mask for one-man-torpedo

Box 2.

22. 1 Druckminderer D 4100 B
Pressure reducing valve D 4100 B

23. 1 HAS 16 vollst. m. Füllrohr v. Aufziehvorrichtung (o Atemschl).
Parachute oxygen bail-out apparatus.

24. 1 gr. Druckmesser ± 400 mm WS
Pressure gage to ± 400 mm waterpressure

25. 1 Kugelgelenk f. Drickanzug
Sleeve joint.

26. 4 Schachteln Zubehör f. CO_2-Messampullen
CO_2 Estimation ampules, packet.

27. 2 Schachteln CO_2-Messampullen
CO_2 ampules, packet

28. 1 U-Höhenatmer m. Luftregler
High altitude breathing apparatus.

29. 1 Ventil für Farbspritzschutzgerät
Valve for paint sprayer

30. 1 Mikrofon f. Höhenatemmaske
Microfone for high altitude breathing mask

31. 1 Prüfzange f. Schnelltrennstelle
Tester for the disconnect

32. 1 Rückschlagventil
Check valve for oxygen installation

33. 4 Beru-Bänder
Hose clamps

34. 1 Druckminderer f. "Seehund" u. "Marder"
Pressure reducing valve for "Seehund" a. "Marder".

35. 1 Druckmesser 0-500 kg/cm^2
Pressure gage to 500 kg/cm^2

<u>Box 3.</u>

36. 1 Kalkbehälter f. U-Boot
Canister for Soda Lime

<u>Box 4.</u>

37. 1 Drickanzug vollest
Pressure suit

38. 1 Druckanzug unvollst
Pressure suit incomplete

6. <u>DOCUMENTS AND RECORDS ACQUIRED BY TEAM</u>

Originals of the most important documents and records, photostatic copies of others and various publications of interest were forwarded to the Secretariat of C.I.O.S. as prescribed.

The report refers to these documents and records which have been indexed as follows:

1. Zeichnungen vom Höhenatmer-Sitzfallschirm
   Drawings of Parachute oxygen bail-out apparatus

2. Bilder " " " "
   Pictures " " " "

3. Lieferbedingungen " " "
   Specification " " "

4. Versuchsergebnisse
   Research Results

5. Zeichnungen vom Sauerstoff-Anzeiger
   Drawings of combination pressure gage and oxygen indicator

6. Lieferbedingungen " " "
   Specification " " "

7. Beschreibung des Apparates
   Descriptions of apparatus

8. Beschreibung alter Sauerstoff-Masken
   Descriptions of older masks

9. Lieferbedingungen alter Masken
   Specifications of older masks

10. Versuchsbericht Nr. 39 - Untersuchung der Kälteempfindlichkeit des Dosierrohres für H.A.S. 130 und H.A.S. 160.
    Research Report Nr. 39

11. Einbauvorschrift für Sauerstoff-Bordanlagen
    Instruction of oxygen installation in German aircraft.

12. Hochdruckschlauch
    High pressure Hose.

13. Aufz. hvorrichtung für Selbsttrennstelle
Tool for mounting the quick disconnect for high altitude emergency oxygen equipment

14. Prüfgerät für O_2-Wächter
Testing device for oxygen blinker

15. Umsteuerhöhenatmer ohne Luftregler
Safety pressure regulator without automatic air dilution.

16. Lieferbedingungen des rüfgerätes für Heeresatmer
Specification for the universal test apparatus

17. Prüfeinrichtung für Universal-Prüfgerät
Test set-up for the universal test apparatus

18. Membranlungen-Ausführung
Development of demand regulators

19. Höhenatmer-Sitzfallschirm H.A.S. 16F
Parachute emergency bail-out oxygen equipment

20. O_2-Anzeiger Zeichnungen
Oxygen indicator drawings

21. CO_2-Messgerät, Beschreibung
CO_2-measuring apparatus, description

22. Höhenatmer für Sitzfallschirm HAS 13 C, Bedienungsanweisung
Parachute emergency bail-out oxygen equipment

23. Rettungsfallschirn mit Höhenatmer 10-6521 A-1
Description of parachute including oxygen equipment.

24. Vorläufige Technische Lieferbedingungen f. Durchgangsventil
Specification for checkvalve, high pressure

25. Trocknung von Sauerstoff für Höhenatmer
Drying of high pressure oxygen

26. Dräger-Taucherautomat D 6000
Dräger automatic pressure reducing regulator for diving suit.

27. Unterwasser-Schwebesteurung
Description of valve for buoys which float under the water surface.

28. Sauerstoff-Zusatzregelventil für U-Boote
Regulator for adding oxygen to air in submarines.

29. Druckminderer für Druckluft auf U-Booten
Regulator maintaining pressure in submarine

30. Sauerstoff-Druckminderer-Anlage für Dieselmotor-Kreislaufbetrieb
Regulator for an oxygen circulating system for dieselmotor in submerged submarines.

31. Sauerstoff-Druckminderer Anlage für Benzinmotor-Kreislaufbetrieb
Regulator for an oxygen circulating system for gasoline engines in submerged submarines.

32. Druckminderer für GM-1 Anlagen
Regulator for adding nitrous oxide to aircraft engines for power bursts at altitude.

33. Pressluftarmatur D-FB
Regulator for aircraft landing gear driven by compressed air.

34. Druckminderer D 5565
Pressure regulator D 5565 and D 4304

35. Mitarbeit des Drägerwerks an Druckminderern für V-Waffen
Regulators developed by the Drägerwerks for V-weapons

36. Der Einheitsdruckminderer für technische Gase
Standard regulators for gases

37. Druckminderer D 6670
Pressure regulator D 6670

38. Sauerstoff-Drucknopfventil für Mesreskämpfer
Oxygen pushbutton regulator for swimming suit

39. Schleppgerät zum Fotographieren von Unterwasser-Objekten
Device for photographing underwater objects

40. Gerät zum Anblasen eines Kreisels für U-Boote
Regulator for supplying air for gyroscope instruments in submarine

41. CO_2-Druckminderer für Torpedobelüftung
CO_2 Pressure reducing regulator for torpedo tube ventilation.

42. Dräger-Schutzpatrone
Dräger safety capsule for welding apparatus

43. Aussenbordanschluss mit Absperrventil
Felling valve for oxygen installation
Drawings

44. Lieferbedingungen fur Umsteuerhöhenatmer 10-137 G
Specification for demand regulator

45. D. (Luft) T Umsteuerhöhenatmer mit Atemschlauch 10-137
Handbook for demand regulator

46. Lieferbedingungen für Umsteuerhöhenatmer 10-137 H
Specification for demand regulator

47. a. Lieferbedingungen für Dichtprüfgerät für Höhenatmer 10-139
Specification for leak tester for demand regulator
b. Dichtprüfgerät für Höhenatmer

48. Dichtprüfgerät für Höhenatmer, Zeichnungen
Leak tester for demand regulator, drawings

49. Lieferbedingungen für Einfriersichere Höhenatemmaske
Specification for frostproof oxygen mask

50. Entwicklungen des Druckanzug
Development of the pressure suit

51. Taucher-Pressluftanlage
Diver compressed air installation

52. O_2-Umfüllanlage
Oxygen transfer system

53. Tauchretter
Underwater escape apparatus

54. Schreibgerät Zeichnung
Pressure recording apparatus

55. Dräger-Hochdruck Umfüllpumpe
High pressure compressor

56. Dräger-Hochdruck-Umfüllpumpen, Handpumpe
High pressure compressor handpump

57. Farbspritzschutzgerät mit Pressluftversorgung
Spraypaint protektive apparatus

58. Zusatzsauerstoffanlage für Bf 109 E
Oxygen installation for Bf 109 E

59 Fliegerschwimmweste
Flight Life Jacket

60. Dräger Höhenatemgerät
Dräger High altitude regulator

61. Atem-Notkupplung 10-87 A
Breathing emergency cappling (Y-connector)

62. Dichtprüfgerät für Höhenatmer
Leak tester for demand regulator

63. Prüf- und Einstellgerät für die Schnelltrennstelle d. Hohenatm.
Testing and installation tool for the quick disconnect

64. Lieferbedingungen für Bauteile der Sauerstoff-Bordanlage
Specification for aircraft oxygen installation

65. Beschreibung der Schwimmweste
Description of life jacket

66. Unterlagen über Patente
Patent descriptions including continuous safety pressure devices, ventilated goggles, pressure equalizing mechanisms, suction apparatus reducing regulators.

VENTILATION AND AIR-PURIFICATION

SUBMARINES TANKS

AIR RAID SHELTERS

Geheim Documents

201. Reprebung des "Sauerstoffzusatzregelventils mit Umwälzinjektor" auf Kleinfahrzeugen der Kriegsmarine. Lubeck, den 1.9.44.

202. Similar 1.9.44.

203. Similar 1.9.44.

204. Luftaufbereitungsanlage "HECHT" - Beschreibung und Betriebschrift, Einbauverschrift - (i.e. B.u.B.E.) - 25 pages

B.u.B. für die Luftaufbereitungsanlage der Unterseeboote Type "Hecht" 1944. Engineer Diploma Eng. Köppel.

205. Similar. 25 pages 18.9.44.

206. Similar 1944

207. Luftaufbereitungsanlage "Seehund" B.u.B.E. 25 pages 1944

208. Similar 1944

209. Type XXI in Nasoogen-Anlage
B.u.B. für die Luftaufbereitungsanlage der Unterseeboote Type XXI, 1944.

210. Lufterneuerungsanlage "HAI" B.u.B.E.
30 pages, 1944. Engineers. Diploma Eng. Köppl and Nielsen

211. Lufterneuerungsanlage "Marder II"
23 pages, 1944.

212. Similar, 23 pages 1944

213. Similar, 23 pages 1944

214. Similar, 23 pages 1944

215. Forschungsinstitut Monats- und Besprechungs-
berichte.
Lubeck, 16 Sept. 1942
Besuch beim Forschungsinstitut für Kraftfahr
wesen und Fahrzeugmotoren in Stuttgart-Unter-
türkheim am 11 Sept. 1942.

Anwesend: Herr Dr. Ernst of the Forschungsinst.
Herr Koch, Dragerwerk
Herr Dr. Meier-Windhorst, Drägerwerk

<u>Address</u>: Stuttgart-Untertürkheim, Martin-Schrenkweg

<u>Leiter:</u> Prof. Dr. Ing. W. Kamm.

216. B.u.B. für den CO_2-Verdichter Nr. 216 der Firma Drägerwerk, Lubeck, für U-Boote Type 26 W. Baujahr 1945.

217. Kalkbehälter - Lufterneurungsgerät.

218. Umwälzlüfter - L 200/U 1 1944

219. B.u.B.E. Luftaufbereitungsanlage der Unterseeboote.

Type 21, 1944
Type 26, 1945

U-Boote Umwälzlüfter L 200 U 1
U-Boote Raumlüfter L 400/U 1
U-Boot Raumlüfter L 1000/U 1

220. Details of injektor air-purification systems of midget submarines. 1944

221. Lufterneuerungsanlage mit Umwälzinjektor H 1

222. Lufterneuerungsanlage mit Umwalzinjektor H 1 + S 2.

223. Tank ventilation and anti-gas drawings.

Belüftunge Panther G. S.L.-A, 6-3
Belüftung Tiger B. S.L.-A, 6-1

224. Diagrams. S/M silenced main ventilation blower

Type L 1000/U 1
L 4000/U 1
L 4200/U 1

225. CARTON CYLINDER containing general drawings of gas-proof shelter-ventilation systems

N.B. signifies a FILE, otherwise FOLDER to be understood.

226. Instructions for operating Umwälzinjektor valves for small underwater craft.

"Seehund" I
"Marder" II
"Hai"

227. Experimental project for a small submarine driven by an oxygen construction engine.
227 a. Kreislaufbetrieb Motor D.W.
227 b. Vergleich verschiedener Verfahren zur Entfernung der "uberschüssigen Schwaden aus dem Kreislauf eines Verbrennungsmotors mit Kreislaufbetrieb
227 c. Das 2 - resp. 4 - Mann - U - Boot
227 d. Das Klein - U - Boot

228. Raumlüftungsplan und Raumluftkühlanlage für Unterseeboote Type IX D 1.

229. Rehrplan für Raumlüftung. (Large supply S/Ms).

230. Plans and drawings "Das Klein-U-Boot" (The small U-Boat).

250. Publications on "Pressure Reducing Regulators"

251. Taucher Technik - Handbuch für Taucher von Hermann Stelzner 1943.

252. Draeger Taucher Gerät DM 40 - Gebrauchsanweisung T 1. 2-2 February 1943.

Draeger Taucher Gerät DM 20 - Gebrauchsanweisung T 1. 2-1 April 1943.

253. Publications - on items produced by Draegerwerk

254 Secret publications on various subjects

255. Brief prepared by Dr. Dräger concerning the works

256. Index of Cabinet containing microphon, plans and drawings of various items produced.

257. Plans for Gas Mask and Canisters Nos. 30 and 38.

258. Tauchergeräte

259. Report prepared by Dr. Dräger on anti-gas warfare "Hinweise für den Bau von gassicheren Luftschutz-Klein-deckungsgräben" - Marz 1945.

260. Report about the Chemical Department prepared by Dr. Stampe, chief of the Department.

Key to Numbers on Certain Documents

Certain documents contain one or the other of these numbers. All documents with the same number relate to the item indicated.

100 Parachute Emergency Bail Out, O_2system.
101 CO_2 Measuring Apparatus.
102 CO_2 Combination Indicator
103 Pressure Suit
104 Universal Test Apparatus
105 Demand Regulator
106 Oxygen Blinker
107 Reducing Regulator for Seat Ejection Apparatus
108 Safety Capsule for Welding Apparatus
109 O_2 Mask
110 Leak Tester for Aircraft O_2 System

7. <u>GENERAL IMPRESSIONS</u>

A. The firm "Dragerwerk" was efficient in all respects.

B. Master Drager said "every effort had been made on life-saving rather than on life-destroying ideas and apparatus". Our investigation shows that this was rather a true statement.

C. Research and development carried out by the firm was of the highest caliber.

D. From a developmental point of view, their most impressive accomplishment related to regulators, including the demand regulator. The investigators were impressed by the width of the range of these regulators. Their accuracy is still to be verified, but if the general accomplishment of the firm is a good index they are good regulators.

E. For the last year of the war very heavy emphasis had been placed on production of civilian gas masks and the general protection of the civilian population. The Dragerwerk was charged with this responsibility. In this connection it is interesting to record a statement by Dr. Drager "We never intended to use gas because we were not prepared to receive it. We were of the opinion that people in glass houses should not throw stones".

F. In production, the only real difficulty experienced was the lack of rubber. Other than this all their raw material seemed to be of the best quality.

G. The Germans appear to be well ahead of the Western Allies in air purification of submarines, especially in small craft, namely the one and two man U-boats. If their claims are correct, the silent motor described is superior to any we have thus far seen.

H. It is interesting to note here that the Germans had perfected a U-boat with a submerged speed of more than 20 knots. Furthermore, they had designed a midget submarine capable of a reported underwater speed of about 60 knots. This was to be jet propelled.

Submitted by
Team Leader

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